THE ZOOspore OF OLPIDIUM RADICALE

By L. LENE LANGE* AND LAURITZ W. OLSON
Institute of Genetics, University of Copenhagen, Øster Farimagsgade 2A, DK-1353
Copenhagen K, Denmark

An ultrastructural study is presented of the unusually large zoospore (c. 8 μm long) of the root-inhabiting uniflagellate Phycomycete, Olpidium radicale Schwartz & Cook (synonyms: Olpidium cucurbitacearum Barr and Pleotrachelus bornovanus Saht.). The study has revealed ultrastructural characters unique to this organism: (1) the axonemal fibres extend through the body of the zoospore (app. 7 μm); (2) the presence of a multiple layer of rough endoplasmic reticulum encircling or partially encircling the lipid bodies; (3) the presence of contractile-like vacuoles. These observations do not support the recognition of a close taxonomic relationship between this species and O. brassicae (Woronin) Dang.

The form and flagellation of the aquatic Phycomycete zoospore is of primary importance in the taxonomic differentiation of the chytridiaceous fungi (Sparrow, 1942, 1958, 1960), especially among the holocarpic, endobiotic species, as these have few constant morphological characters (i.e. sporangial form and ornamentation) which do not vary with the growth environment.

The discovery that certain root-inhabiting olpidiaceous species may serve as vectors for soil borne plant viruses emphasizes the need for critical developmental, morphological, and ultrastructural studies of these species so that definitive taxonomic determinations can be made. Studies of the zoospore of olpidiaceous species are needed as the structure of the zoospore can serve as a taxonomic tool in differentiating species. Further, it is the zoospore with which the virus is associated and by which it is transmitted.

Lange & Insunza (1977) presented a general description of the root-inhabiting fungus Olpidium radicale Schwartz & Cook (1928), which is suspected to be a vector for the red clover necrotic mosaic virus (Gerhardson, pers. comm., 1976). On the basis of an evaluation of morphological and host range characters of this fungus, Lange & Insunza (1977) concluded that Pleotrachelus bornovanus Saht. (1962) and O. cucurbitacearum Barr (1968) are synonyms of O. radicale.

The present investigation includes light and electron microscopic studies of the zoospores of O. radicale isolated from Cucurbita roots and O. radicale from red clover roots. As no morphological or ultrastructural differences have been observed between the two isolates they will be considered as simply the zoospore of O. radicale.

MATERIALS AND METHODS

Isolates of O. radicale used in this study were: (1) O. radicale isolated from roots of Trifolium pratense L. growing in a field near Uppsala, Sweden, kindly provided by Dr Gerhardson, Department of Plant Pathology and Entomology, Uppsala, Sweden; (2) O. radicale sub nom. O. cucurbitacearum provided by Dr Dias, Vineland Station, Ontario, Canada. The two isolates were maintained in roots of T. pratense or C. sativa L. respectively.

Propagation of the fungus was by zoospores. Zoospore discharge was induced by immersing the infected roots in a dilute salt solution (DS/4) (Dill & Fuller, 1971; DS diluted three times with distilled, deionized water) and pipetting 5-10 ml of the zoospore suspension onto pots with plants of either T. pratense or C. sativa (1-2 weeks old). 7-10 days later the heavily infected roots were used as source material for producing the next zoospore suspension.

For EM preparation of zoospores, zoospore discharge was induced by quickly washing the roots in running tap water followed by immersion for 1/2 h in cool (c. 15°) DS/4. It was found that a mild shaking of the root-DS suspension stimulated zoospore discharge. The fixation technique used is that of Olson & Fuller (1968) as modified by Lange & Olson (1976a). Zoospores were fixed for 20 min at 23° in an unbuffered 1% glutaraldehyde solution, pH 6.8, in DS; 2% purified glutaraldehyde was added (slowly) to an equal volume of zoospore suspension. After three changes...
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in DS the zoospores were postfixed for 20 min at 23°, in 1% OsO₄ in 0-05 M-KH₂PO₄-buffer, pH 7.0. The zoospore pellet was embedded in warm agar (45°) and subsequently dehydrated in a graded ethanol series. After three changes of 100% ethanol the pellet was cut into mm³ pieces and washed in three changes of propylene oxide and then infiltrated and embedded in Spurr's resin (Spurr, 1969). Sections were cut with a diamond knife, stained in 50% ethanol solution saturated with uranyl acetate followed by Reynolds lead citrate (Reynolds, 1963) and examined with a Siemens 1A electron microscope at 80 kV, or a Philips 201 S at 60 kV.

RESULTS

Zoospores

The actively swimming zoospore of O. radicale is elongate (Figs. 1, 2) to obpyriform in shape and 7-8 μm long, considerably larger than most chytridiaceous zoospores. Rounded zoospores (Fig. 1a), measuring c. 5 μm diam, and zoospores with a constricted central region may often be observed. Recently discharged zoospores remain immotile around the orifice of the sporangial exit tube for up to several minutes, after which time they swim away with a slow, steady movement.

The nucleus is located in the anterior end of the zoospore, measures 2-1-2.6 μm diam (Figs. 1, 1a, 2), has an invagination (Fig. 3) at the posterior side opposite to where the functional and vestigial kinetosomes are located and an evagination most often neighbouring the invagination, but closer to the cell surface. Electron dense areas of condensed chromatin are visible at the periphery of the nucleus (Figs. 1, 2, 4). Outside the nucleus and opposite the nuclear evagination, is an area of osmiophilic material which at its periphery appears to be an aggregation of ribosomes but has a more amorphous appearance at its centre (Fig. 4). A gradient in the distribution of the cellular ribosomes exists; the ribosomes are more concentrated in the anterior region of the spore than in the posterior (Figs. 1, 2). The functional and vestigial kinetosomes (Figs. 2, 5) are located in the concavity of the posterior invagination of the nucleus. The axonemal fibrils extend from the functional kinetosome through the length of the zoospore body, continuing into the flagellum at the posterior end of the zoospore (Fig. 1). The whiplash flagellum is approximately 21-23 μm long.

Mitochondria vary in size and shape and may be branched. Ring-like mitochondria, enclosing an area of the cytoplasm, have also been observed (Fig. 1). Mitochondria are mainly found in the anterior region of the zoospore (Figs. 1, 2, 5), lipid bodies (c. 0.5-0.8 μm diam) in the central region, and the vacuoles and multivesicular bodies dominate in the posterior region. This organization of organelles gives the elongated zoospore of O. radicale an ultrastructurally compartmentalized appearance (Figs. 1, 2).

Structural associations

Most mitochondria are located around the nucleus (Figs. 1, 2, 5) but have no evident association with the kinetosomes. The invagination and the evagination of the nucleus of O. radicale are always structurally associated with one or more mitochondria (Figs. 3, 15, 26). Similar configurations have been observed in spores of the Blastocladiales, for example, in the zoospore (Fuller & Olson, 1971) and the meiospore (Olson, 1973) of Allomyces. In Allomyces the nucleus has a distinctive evagination into the basal mitochondrion. The location of the kinetosomes in a concavity of the nucleus (Figs. 2, 5, 15, 16, 23, 26) may be compared to the position of the rhizoplast and the kinetosomes in the zoospore of Olpidium brassicae (Woronin) Dang. (Lange & Olson, 1976b).

The presence of large amounts of rough endoplasmic reticulum (rER) is not commonly observed in fungal cells. However, concentric rings of rER have been described from a few biflagellate zoospores, e.g. Phytophthora megasperma Drechsler (Ho et al., 1968) and Pythium proliferum de Bary (Lunney & Bland, 1976). The configuration of rER in concentric rings encircling lipid bodies

EXPLANATION OF FIGURES 1–26

Abbreviations

| A | Internal axoneme |
| B | Structure reminiscent of nuclear cap |
| C | Dictyosome |
| D | Functional kinetosome |
| E | Functional and vestigial kinetosomes |
| F | Lipid body |
| G | Lipid body encircled by rER |
| H | Mitochondrion |
| J | Microbody |
| M | Multivesicular body |
| N | Nucleus |
| P | Props |
| TP | Terminal plate |

Fig. 1a. Light micrograph of an Olpidium radicale zoospore. ×3000.

Figs. 1, 2. Sequential, longitudinal sections of a zoospore of O. radicale. ×16700.
Zoospore of Olpidium radicale
observed in the present study of *O. radicale* zoospores (Figs. 1, 2, 7, 8) closely resembles the structure described by Lunney & Bland (1976) though in *P. proliferum* it encircled a mitochondrion. Lunney & Bland (1976) also observed large amounts of layered rER associated with the nucleus in the zoospore of *P. proliferum*. An association of rER and the nucleus, similar to that observed in the present study has been seen in zoosporangia of *O. radicale* and *O. brassicae* during sporogenesis (unpubl.). In the work of Lunney & Bland (1976) attention is drawn to the fact that not only may the arrangement of ribosomes on the rER change with the different stages of the life cycle, but radical changes may also take place during the motile phase of the zoospore.

Most of the microbodies are associated with lipid bodies (Fig. 6), but they may also be associated with the smooth endoplasmic reticulum and with mitochondria. A characteristic feature of the zoospores of *O. radicale* is a configuration of rER encircling one, or several, lipid bodies (Figs. 1, 2, 7, 8). A single lipid body may be partly encircled by rER and also be contiguous with a microbody.

A single dictyosome is present in the zoospore of *O. radicale* (Figs. 2, 9) and it is in a fixed position alongside the internal axonemal fibres (in the anterior to mid-portion of the zoospore).

**Vacuoles**

Almost no vacuoles are found in the anterior portion of the zoospore (Figs. 1, 2, 5). However, numerous vesicles, probably derived from the dictyosome, are found in the mid-region of the zoospore, posterior to the nucleus (Figs. 2, 9). Two other types of vacuole are found to dominate in the posterior portion of the zoospore of *O. radicale*: (1) a vacuole containing an irregular electron dense precipitate bounded by a thin, rather uniform layer of precipitate in addition to the vacuolar membrane (Fig. 10); (2) a vacuole which may be designated a multivesicular body as it contains numerous vesicles; these can be either loosely (Fig. 11) or densely (Fig. 12) packed. Sometimes the vesicles are interspersed with a more electron dense precipitate, thus comprising an intermediate type of vacuolar organization (Fig. 2). At the light microscope level the mid-region and the posterior part of the zoospore seem to be 'sunken in'. The 'sunken in' regions in thin sectioned material are shown in Figs. 1, 2, 13 and 14. These regions are characterized by the presence of vacuoles of different size, content, and with one or two membranes; and by the very diffuse appearance of the plasmalemma (Figs. 1, 2, 14).

**Flagellar apparatus**

The rootlet. From Figs. 15-19 it appears that an electron dense bar is situated between the kinetosomes and the nucleus. Depending on the plane of section, the bar appears as a dense spot (Figs. 17-19), a somewhat triangular structure (Fig. 15) or elongated (Fig. 16). This electron dense structure is connected with the functional and the vestigial kinetosomes by filaments originating from the different elements of the kinetosomes (see below) (Figs. 15, 16, 19). The electron dense bar and its associated fibrils may be designated as a rootlet structure. No cross striation of the rootlet fibrils has been observed.

**Internal axoneme.** The axonemal fibres extend through the body of the zoospore from the functional kinetosome to the plasmalemma (c. 7 µm). This structure is barely visible with the light microscope, but may account for the striking swimming motion of the zoospore of *O. radicale*.

Figs. 17-19 show serially sectioned material from which it appears that the terminal plate (TP) in this species is an electron dense structure with a characteristic central hole (Fig. 18). In the axonemal lumen may be found numerous vesicles (Fig. 18) and ribosome-like particles (Fig. 19). The anterior portion of the internal axoneme (i.e. the part closest to the kinetosome) consists of doublets (of A and B fibres) with an attached, partially formed C fibre (the terminology follows that proposed by Gibbons & Grimstone, 1960) without a pair of central fibres (Fig. 18). Further, characteristic of this part of the internal axoneme is a structure which, in longitudinal sections, has the appearance of a 'stippled line' parallel to the axonemal fibres (Figs. 19, 20). The cross
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striations between the outer and central microtubule doublets (Fig. 21) are interpreted as being the radial spokes of the axonemal fibres (Warner & Stir, 1974, Figs. 3, 4).

Fig. 22 shows, in longitudinal section, two of the nine props which radiate from the axonemal doublets connecting them to the cell surface at the posterior end of the zoospore; and Fig. 23 shows five of the nine props surrounding the vestigial kinetosome. No props have been observed around the functional kinetosome. However, some electron dense amorphous material may be associated with the axoneme at the level of the terminal plate (Fig. 18).

Kinetosomes. The lumen of the functional and the vestigial kinetosomes (shown in cross section in Fig. 5 and in longitudinal section in Fig. 15) contains a layered (Fig. 18) cartwheel structure (Figs. 5, 23, 24) which connects the outer system of triplet microtubules (A, B and C fibres) with the inner central axis, in which an axole pin is located (Fig. 23). A-C bridges interconnecting adjacent triplets may be observed (Fig. 24). The cartwheel structure has an electron-dense thickening close to the A fibres; this is shown in cross-section in Fig. 24.

Figs. 23-25 represent gradually more posterior sections of the vestigial kinetosome. The micrograph in Fig. 25 shows the posterior part of this kinetosome, indicating that the vestigial kinetosome is composed of a triplet microtubule region and a short region of doublet microtubules to which are attached partially formed C fibres.

**DISCUSSION**

Zoospores

The electron-dense material adjacent to the nucleus of the zoospore of *O. radicale* (Figs. 1, 2, 4, 26) resembles a nuclear cap by its positional relationship to the nucleus and by the aggregated ribosomes observed at its edge (Fig. 4). However, as the diffuse nature of the interior of this aggregate more resembles the diffuse region of a nucleolus (Fig. 4), and as the structure is not enclosed by an aggregation of mitochondria or by an encircling double membrane it cannot be designated a nuclear cap *sensu Allomyces* (Fuller & Olson, 1971), * Blastocladiella* (Cantino et al., 1965) or *Phlyctochytrium aestuarii* Ulken (Lange & Olson, 1977).

Until more is known about this structure it should be recognized as being reminiscent of a nuclear cap.

The abnormally large and elongate zoospore of *O. radicale* is easily studied with the light microscope, and its size and shape are characteristic of the species. The compartmentalization of organelles within the zoospore can be seen in the electron microscope (Figs. 1, 2, 26). In the anterior portion of the zoospore are located the nucleus, a structure reminiscent of a nuclear cap, mitochondria, and the functional and vestigial kinetosomes; in the mid-portion are located a dictyosome, lipid bodies, rER, a few mitochondria, microbodies, multivesicular bodies, and vacuoles with an electron dense precipitate. In the posterior end of the zoospore are found rER, vesicles, multivesicular bodies, vacuoles with an electron dense precipitate, and the props which surround the axonemal microtubules and appear to attach them to the plasmalemma.

It is remarkable that neither gamma bodies (*sensu Myers & Cantino, 1974*) nor gamma-like bodies (*sensu Lange & Olson, 1976a*) have been observed in the zoospore of *O. radicale*. The multivesicular bodies described here are quite different from those which Temmink & Campbell (1969) described as multivesicular bodies in the zoospore of *O. brassicae*, which according to Lange & Olson (1976a) should be designated gamma-like bodies.

The zoospore of *O. radicale* has a single dictyosome located adjacent to the axonemal fibres in the anterior portion of the zoospore (Figs. 2, 9). Small vesicles are abundant around the axoneme in the anterior to mid-portion of the zoospore (Figs. 1, 2). These vesicles are interpreted as part of a system of dictyosome derived cisternae rather than vesicles of smooth ER. The position of the dictyosome alongside the axoneme in the zoospore of *O. radicale* should be compared with the description of the zoospore of *Rosella allomyces* Foust (Held, 1975), in which a dictyosome is

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**Fig. 9.** The single dictyosome of the zoospore of *O. radicale*. × 70,800.

**Fig. 10.** A vacuole containing an irregular electron dense precipitate enclosed in a thin, rather uniform layer of precipitate (arrow). × 83,000.

**Fig. 11.** Multivesicular body loosely packed with vesicles. × 70,400.

**Fig. 12.** As Fig. 11, but with more densely packed vesicles. × 70,400.

**Fig. 13.** A system of vacuoles, next to the surface, which is interpreted to function as a contractile vacuole. × 26,800.

**Fig. 14.** As Fig. 13; the diffuse nature of the plasmalemma (arrow) is interpreted to indicate that a fusion of the vacuoles has taken place. × 58,500.
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located adjacent to the rhizoplast and the kineto-
somes, and with the rhizoplast associated vesicles
in the zoospore of *O. brassicae* which Lange &
Olson (1976b) have interpreted as being vestiges
of a dictyosome. These observations on a structural
association between the flagellar apparatus and the
dictyosome are consistent with the observations
by Pitelka & Child (1964) on the locomotor
apparatus of ciliates and flagellates. Reports are
available on the presence of a dictyosome in the
zoospore of the Monoblepharidales (*Oedogonia-
myces*, Reiche, 1972) and Harpochytriales (*Harpo-
chytrium*, Travland & Whisler, 1971). The presence
of a dictyosome in the zoospore of *O. radicale*
necessitates a re-evaluation of the generally held
view that the chytridialian zoospore lacks a dictyo-
some.

Structures similar to the contractile vacuole
described from protozoa and algae have not yet
been observed in the zoospore of uniflagellate
Phycomycetes. However, among the biflagellate
Phycomycetes, reports on the presence of a con-
tractile vacuole have been made (e.g. *Aphanomyces
euteiches* Drechsler (Hoch & Mitchell, 1972) and
*Phytophthora palmivora* (Butler) Butler (Bimpong
& Hickman, 1975)). The structure shown in Figs. 1,
2, 13, and 14 differs from previous descriptions of
contractile vacuoles in the biflagellate Phycomy-
cetes in the apparently irregular arrangement of
the vesicles. However, for several reasons we
favour the designation of this structure as a con-
tractile vacuole: (1) In the light microscope the
size of this structure may be observed to vary;
(2) In thin sectioned material the vesicles are
seen in positions which are interpreted as demon-
strating fusion of the small vesicles with the
larger vacuole (Fig. 13) and fusion of the larger
vacuole with the plasmalemma of the zoospore;
(3) The plasmalemma may be observed to have
a very diffuse appearance where the apparent
fusion of the vacuole to the plasmalemma takes
place. This diffuse nature of the plasmalemma
outside the contractile vacuole is comparable to
that seen in the zoospore of *P. palmivora* (Bim-
pong & Hickman, 1975).

The different types of vacuoles observed in the
zoospore of *O. radicale* constitute an important
part of the ultrastructural organization of the zoo-
spore. In describing the ultrastructural organization
of this zoospore, the need for a well-defined
terminology to characterize these organelles is
obvious. However, the number and variability of
the vacuolar types observed makes a systemati-
zation of these organelles impossible at present;
further, confusion can arise from the fact that
the final appearance of these structures in the
EM is extremely sensitive to differences in the
preparative technique used. An attempt to system-
atize the descriptions of vascular types has recently
been made by Lunney & Bland (1976) for the
biflagellate Phycomycete zoospore. Unfortunately,
insufficient information is available to systematize
the different types of vacuoles described from
the uniflagellate Phycomycetes.

Flagellar apparatus

The structure between the kinetosomes and the
nuclear envelope, composed of filaments running
from the structural elements of the kinetosomes to
an elongated electron dense bar located close to
the nucleus, is interpreted to be a rootlet of a
rather diffuse substructure. Owing to its incon-
spicuous nature and the lack of any striations or
repeated bands, the rootlet observed in the zoo-
spore of *O. radicale* (Figs. 15–19) is not considered
analogous with the striated rhizoplast described
from *O. brassicae* (Lange & Olson, 1976b), nor
does it resemble the solid rhizoplast described
from *Phlyctochytrium arcticum* Barr by Chong &
Barr (1973).

The vestigial kinetosome (Figs. 23–25) is com-
posed of a region of triplet microtubules and a
short region of doublet microtubules with the
partially formed C-fibre attached. The length of
the vestigial kinetosome of *O. radicale* is inter-
mediate between the very short vestigial kineto-
some described from *O. brassicae* (Lange & Olson,
1976b) which is composed of only triplet micro-
tubules and the long vestigial kinetosome of

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Fig. 15. Longitudinal section of the functional and the vestigial kinetosome; fibrils connect the kineto-
somes to an electron dense triangular structure located between the kinetosomes and the nucleus.
This electron dense bar with its associated fibrils may be designated as a rootlet. ×40000.

Fig. 16. As Fig. 15, but in this plane of section the rootlet bar is elongated. ×72000.

Figs. 17–19. Sequential longitudinal sections of the internal axoneme, anterior to where the central
pair of microtubules are present. The osmiophilic nature of the terminal plate is shown in Figs. 17
and 19, while the central hole in the terminal plate is seen in Fig. 18. Note, Fig. 18 shows a layered
structure (the cartwheel) located in the lumen of the functional kinetosome. The rootlet structure
appears as a dense spot connected with fibrils to the elements of the kinetosome. ×66000.
Zoospore of Olpidium radicale
Phlyctochytrium spp. (Olson & Fuller, 1968) which has both a triplet and a doublet region.

As noted by Olson & Fuller (1968) for Phlyctochytrium spp. the vestigial kinetosome in the zoospore of O. radicale is surrounded by a system of props. However, the functional kinetosome does not have props associated with it. The props observed in Fig. 22 link the plasmalemma of the spore to the axonemal fibres. The diffuse osmiophilic material located adjacent to the axoneme at the level of the terminal plate, in cross sections, does not have the appearance of discrete props and is interpreted to be material analogous to the amorphous osmiophilic material often found surrounding the kinetosomal area. The presence of a terminal plate is reported in several chytridaceous zoospores (e.g. Phlyctochytrium dichotomum Umphlett (Umphlett & Olson, 1967), Phlyctochytrium spp. (Olson & Fuller, 1968), an estuarine chytrid (Phlyctochytrium sp.) (Kazama, 1972). However, the conspicuous hole in the terminal plate of the zoospore of O. radicale (Figs. 17–19) observed here has not previously been noted.

The structure, designated as a ‘stippled line’ (Figs. 19, 20) is most likely the longitudinal section of a spiral or ring-like structure interconnecting the A-fibres of the doublets in the zone of the internal axoneme, posterior to the kinetosome and anterior to the start of the paired, central microtubules. Both the presence of this ring or spiral structure and the remarkably prolonged zone of doublets without a central pair of microtubules are at present considered to be unique for the zoospore of O. radicale. This corresponds to the extraordinarily long extension of the internal axoneme (Figs. 1, 2, 26). The presence of numerous vesicles inside the axonemal lumen (Fig. 19) may be compared to similar observations from the zoospore of Phlyctochytrium irregularare Koch (McNitt, 1974).

**Taxonomic implications**

The taxonomic position of O. radicale is based on sporangial characters (endobiotic, holocarpic sporangia with one or more exit tubes, parasitizing herbaceous roots) in which it is very similar to the better known O. brassicae. (O. radicale is separated from O. brassicae on the basis of a smooth resting sporangial wall against a resting sporangium of a stellate appearance, respectively.) While ultrastructural studies have shown structural similarities between the zoospores of O. brassicae (Lange & Olson, 1976a, b), R. allomycis (Held, 1975) and Rhizophlyctis rosea (de Barry & Woron.) Fischer (Barr & Hartmann, 1977) (by the presence of a very characteristic striated rhizoplast), the results presented here do not support a close taxonomic relation between O. radicale and O. brassicae.

This study of the ultrastructure of the zoospore of O. radicale has revealed the following characters which are unique to this organism: (1) The axonemal fibres extend through the body of the zoospore from the kinetosome to the plasmalemma (c. 7 μm); (2) the presence of a multiple layer of rER encircling or partially encircling the lipid bodies; (3) the presence of contractile-like vacuoles. An evaluation of the similarities in sporangial morphology of O. brassicae and O. radicale versus the significant ultrastructural differences of the zoospores of these organisms may lead to a re-evaluation of the generic position of O. radicale.

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Fig. 20. Longitudinal section of the internal axoneme of the zoospore of O. radicale, showing a structure which appears as a ‘stippled line’ parallel to the axonemal fibres. Vesicles are seen inside the axonemal lumen. × 94000.

Fig. 21. The radial spokes of the axonemal fibres are seen as cross striations between the outer and central microtubule doublets. × 94000.

Fig. 22. Longitudinal section of the distal part of the internal axoneme. Props are seen on both sides of the flagellum, connecting it to the plasmalemma (arrows). × 106000.

Figs. 23–25. Cross sections of the vestigial kinetosome. In Fig. 23 are seen five of the system of nine props which surrounds the vestigial kinetosome. In Figs. 23 and 24 is seen the cartwheel structure with an axle pin at its centre. The arrow in Fig. 24 indicates an interconnexion between the A and the C fibres of the triplet microtubules. Fig. 25 is a cross section of the posterior portion of the vestigial kinetosome, here composed of microtubule doublets to which are attached partially formed C fibres. An internal sheath connects the A fibres of the doublets. Fig. 23, × 112000; Fig. 24, 145000, Fig. 25, 160000.
Fig. 26. Schematic drawing of the organization of the organelles in the zoospore of *O. radicale*. 
REFERENCES


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